

Rapid Development of Aerodynamic Models for UCAV Flight Dynamics & Control Studies

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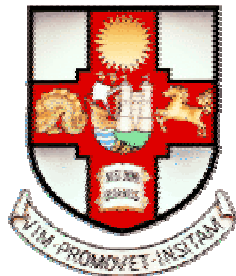
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Are we getting the most out of the UCAV concept?

- unmanned = loss of flexibility
 - mission planning – restricted operational areas & times
 - autonomy – dealing with the unexpected!
- so what are the advantages?
 - cost
 - expendability – D³ missions
- but are these being achieved?
- UCAVs still designed as '*unmanned manned aircraft*'
 - large, complex & expensive
 - long development times & protracted in-service life
 - definitely *not* expendable!



Instead, design for short service life ...

- accept the inevitability of high attrition rate in service
 - ‘wooden round’ concept unworkable
 - launch & recovery accidents etc
 - operating in harms way
- design for short term flexibility
 - high-cost systems transported in low-cost airframe
 - modular ‘plug & play’ architecture – not integrated!
- plan for long term flexibility
 - rapid response to changes in concepts of use
 - take advantage of advances in airframe technology
- design for expendability
 - cost, numbers, replacement time
 - operators *must* be prepared to lose platforms



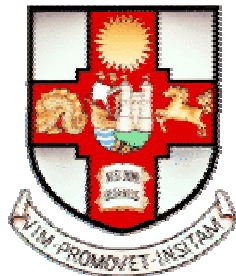
How are we going to do this?

- key factors
 - cost – development & manufacture
 - development time
 - platform flexibility
- look for common element ...
 - the flight control system
 - *design*
 - *development*
 - *clearance*
- what's the problem with current FCS design process?
 - linear process
 - protracted & costly!



Conventional linear FCS design process

- FCS designed & implemented before 1st flight
 - complex, highly integrated systems
 - financial & political implications of accidents in flight test
- FCS design largely simulation based
 - therefore needs high quality aerodynamic S&C model
- extensive platform characterisation required
 - 1000's of hours of wind tunnel testing
 - specialist test facility needs for S&C
- *but* FCS problems still common in early flight test
 - F-16, F-22, Gripen, Dark Star etc ...
- FCS development & clearance now the major element of a flight test programme



An alternative approach?

- do we really need a high level of integration?
 - are performance benefits worthwhile for low-cost UCAV?
 - multiple losses in flight test acceptable for UCAVs
 - basic airframes are cheap, electronics are robust
 - opportunities offered by modern FCS design tools
 - Nonlinear Dynamic Inversion (NDI)
 - *full (or accurate!) aero model not required for basic control*
- coupled with availability of
- low-cost, high-performance computing hardware
 - improved data analysis techniques
 - low-cost, rapid airframe manufacturing methods
 - COTS airframe components



Iterative UCAV FCS development

- combine

- aerodynamic characterisation
- FCS design & development
- platform optimisation
- flight test

in a single integrated, *iterative* process

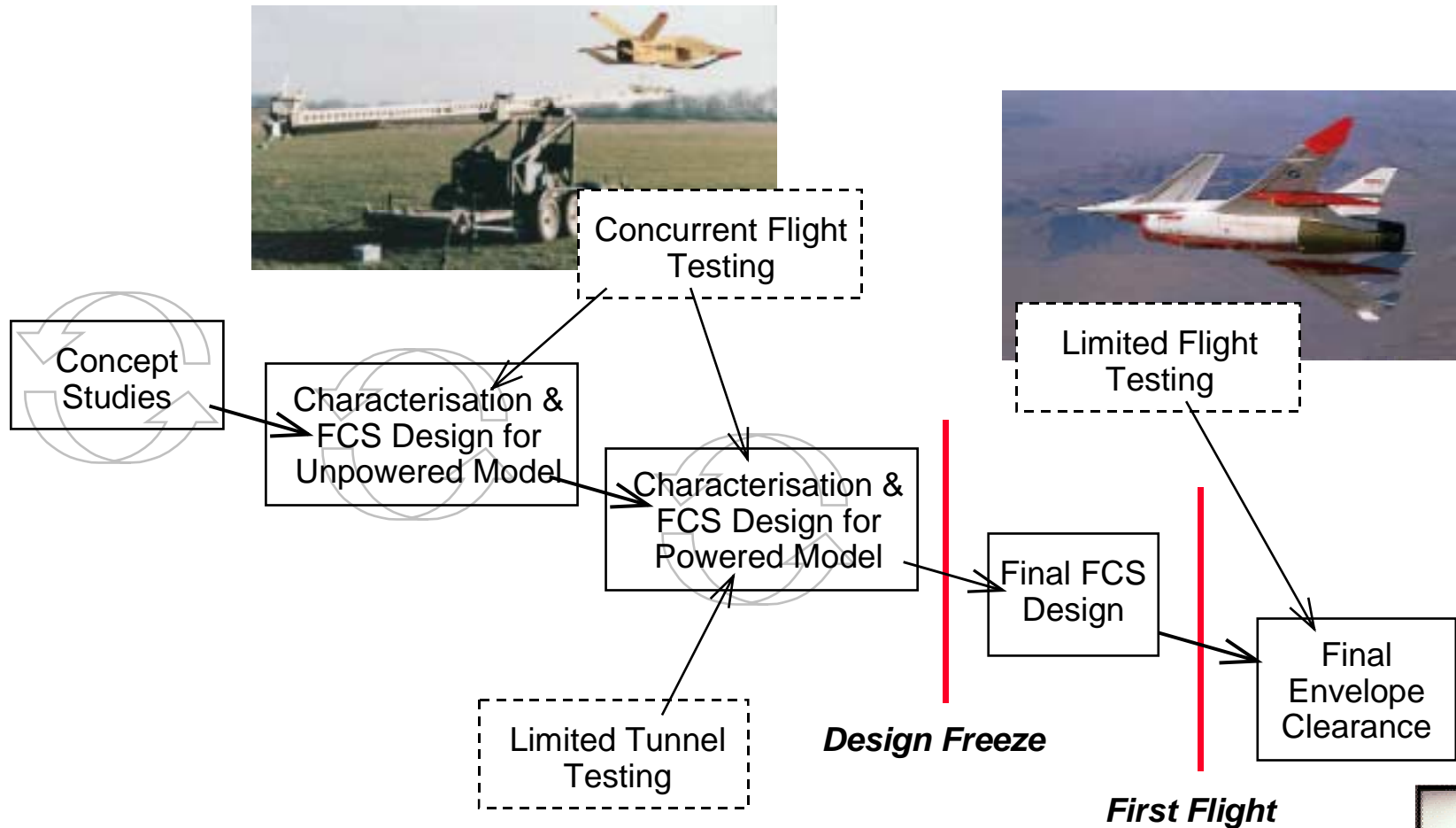
- aerodynamic model and flight control laws developed in *parallel*

- NDI (or similar) coupled with advanced non-linear parameter ID
- recast aero model in control system form – eg aerodynamic transfer function

- final aero model ‘only as good as it needs to be’



A possible iterative UCAV design process



Aspects of an iterative approach

- use industry-standard control system design tools
 - PC-based FCS – maximum use of COTS components
 - desktop design & development environment
 - VAAC Harrier demonstrates potential of this approach
- an alternative 2-stage approach to clearance
 - control system architecture **validated** at sub-scale
 - **verification** of final (auto-coded) implementation
- flexible development process
 - technology insertion opportunities
- continuous risk reduction exercise
- shorter timescales & reduced cost
- ‘fit for purpose’ FCS

